In the name of ALLAH; the Most beneficent the most merciful

EXPERIMENTAL STUDY ON THE INFLUENCE OF ETHANOL AND AUTOMOTIVE GASOLINE BLENDS

By

Dr. Eng. Tarek M. Aboul –Fotouh[1,2]
Eng. Omar A. Mazen[2]
Prof. Dr. Ibrahim Ashour[3,4]

1. Department of Mining and Petroleum Engineering, Al-Azhar University, Egypt. tarekfetouh@yahoo.com
2. Department of Chemical Engineering, British University in Egypt, Egypt.
3. Department of Chemical Engineering, Faculty of Engineering Minia University, Egypt.
4. Zewail City University of Science and Technology, Sheikh Zayed 12588, 6th October, Egypt.

Contents

Introduction

Objectives of the Work

Materials and Methods

Results and Discussion

Conclusions and Recommendations

Introduction

Problems in the World

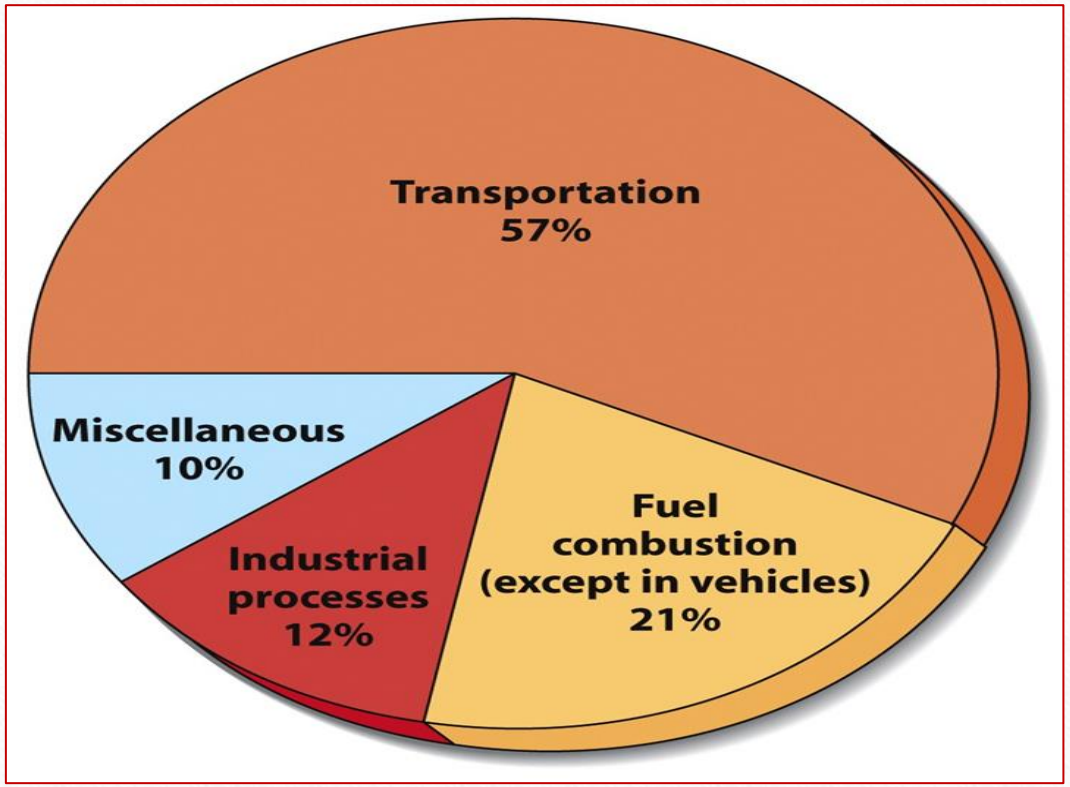
- Energy
- Pollution
- Water Shortage

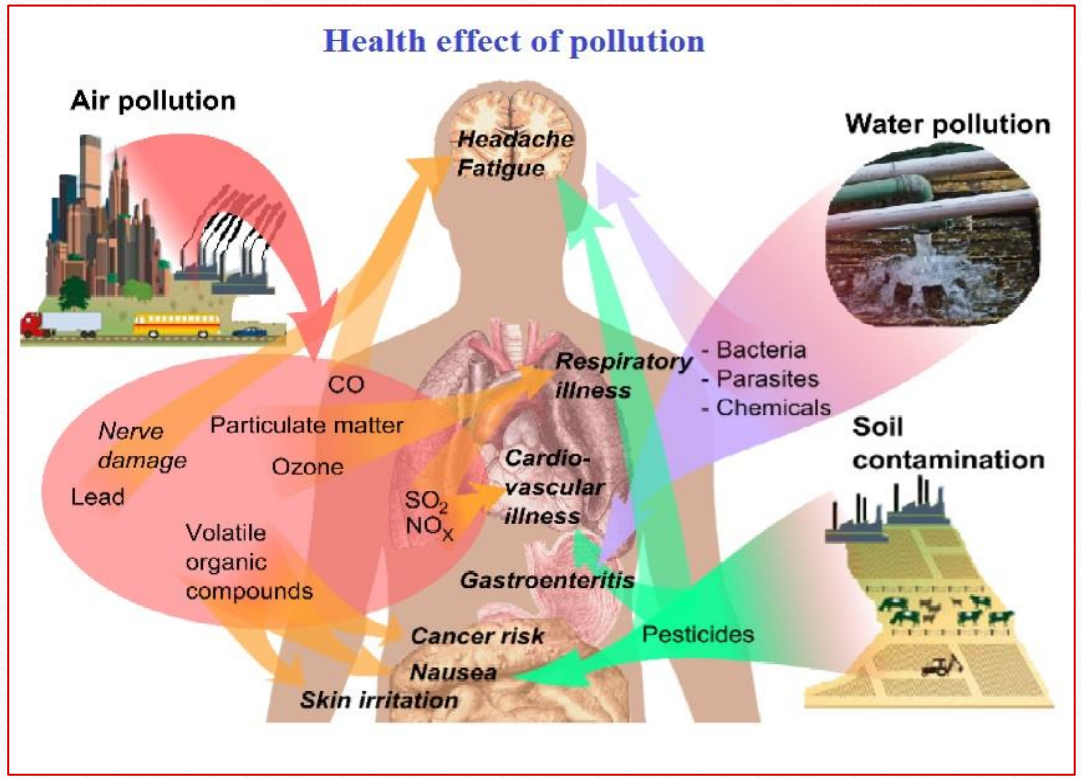
Introduction

- Inhaling or swallowing large amounts of gasoline can cause seizures, unconscio-usness, and death.
- It can also harm the nervous system and cause coma and inability to breath.
- Inhaling high concentrations of gasoline can irritate the lungs.
- Repeated high exposure to gasoline can cause lung, brain, and kidney damage.
- The use of bio-fuel has been found to reduce risks of cancer because it reduces the production of cancer-causing compounds, such as carbon monoxide.
- This research focuses on gasoline-ethanol blends or commonly known as gasohol which produce less air pollution than the fossil fuel.
- This work would contribute to reduction of the threat to the environment from exhaust emissions and global warming.

"Our Environment Our Responsibility"

- **Globally, an estimated 200,000 to 570,000 people die each year form ambient air pollution.**
- **Cars are responsible for 40%-60% of the world's air pollution.**





Objectives of the Work

Objectives of the Work

- The Production of new blends of environmental gasolines with high octane numbers which have less amount of benzene and aromatic contents.
- Study the physico-chemical characteristics of various refinery gasoline-blends of reformate, isomerate, full refinery naphtha (FRN), heavy straight run naphtha (HSRN), hydrocracked naphtha, heavy hydrocracked naphtha, coker naphtha and heavy coker naphtha.
- Investigate the physico-chemical characteristics of gasoline-ethanol blends to obtain the optimum sample.
- The selection according to Euro-3 and Euro-5 standard regulations.

Materials and Methods

Materials and Methods

The materials used to produce environmental gasolines

Sources	Blend-stocks
Crude Distillation	Full Straight Run Naphtha(FSRN) Heavy Straight Run Naphtha (HSRN)
Upgrading Units	Isomerate
	Reformate
Conversion Units	Coker Naphtha HeavyCoker Naphtha
	Hydrocracked Naphtha Heavy Hydrocracked Naphtha
Oxygenated Compounds	Ethanol

Typical Volume Shares and Properties of Standard Gasoline Blend stocks

Source	Blendstock	Typical Share (Vol%)	Typical Properties						
			Octane		Sulfur	RVP	Aromatics	Benzene	Olefins
			RON	MON	(ppm)	(psi)	(vol%)	(vol%)	(vol%)
Crude Distillation	Str. Run Naphtha	5 - 10	71	70	≈ 120	12	-	-	-
Upgrading Units	Isomerate	0 - 10	82	80	1	13	-	-	-
	Alkylate	5 - 10	94	92	< 10	3	-	-	-
	Reformate	20 -30	97	88	< 4	5	60	5	-
Conversion Units	FCC Naphtha	30 - 35	92	80	500 - 1500	5	25	1	30
	Coker Naphtha	0 - 5	88	80	≈ 500	19	0.5	0.5	50
	Hydrocracked Naphtha	5 - 15	78	76	< 4	11	2	2	-
Purchases	Natural Gas Liquids	0 - 5	73	71	≈ 150	13	3	1	1
	MTBE	0 - 15	118	102	< 5	8	-	-	-
	Ethanol	0 - 10	123	103	< 5	18	-	-	-

Materials and Methods

EU REFERENCE TEST FUELS

These specifications apply to reference fuel used during certification/type approval.

UNLEADED GASOLINE FUEL

Values for Euro 3 and Euro 4 are part of European Directive 98/69/EC and 2002/80/EC. For implementation timing see pages 10-11

Parameter	Unit	ECE, EC 93,96	Euro 3	Euro 4
Octane	RON/MON	95/85	95/85	95/85
RVP	kPa	56-64	56-60 [1)]	56-60 [1)]
Density at 15ºC	kg/l	0,748-0,762	0,748-0,762 [1)]	0,740-0,754 [1)]
T 10	ºC	42-58		
T 50	ºC	90-110		
T 90	ºC	155-180		
Dist. at 100ºC	% vol		49-57	50-58
at 150ºC	% vol		81-87	83-89
FBP	ºC	190-215	190-215	190-210
Aromatics	% vol	45	28-40	29-35
Olefins	% vol	20	≤ 10	≤ 10
Benzene	% vol	5	≤ 1	≤ 1
Oxygen	% mass		≤ 2,3	≤ 1
Sulfur	ppm	400	100	10
Lead	g/l	0,005	0,005	0,005
Phosphorus	g/l	0,0013	0,0013	0,0013

[1)] Different values for cold temperature test fuel: RVP: 56-95 kPa, Density at 15°C: 748-775 kg/m³

DIESEL FUEL

Parameter	Unit	ECE, EC 93,96	Euro 3,4
Cetane		49-53	52-54
Density at 15ºC	kg/l	0,835-0,845	0,833-0,837
Distillation T 50	ºC	≥ 245	≥ 245
T 95	ºC	320-340	345-350
FBP	ºC	≤ 370	≤ 370
Flash point	ºC	≥ 55	≥ 55
Viscosity at 40°C	mm^2/s	2,5-3,5	2,5-3,5 [2)]
Polycyclic aromatics	% mass		3-6,0
Sulfur	ppm	≤ 3000	≤ 300 [3)]

[2)] For Euro 4: 2,3-3,3

[3)] Mandatory diesel sulfur level for Euro 4: ≤ 10 ppm

Materials and Methods

EU REFERENCE TEST FUELS

Values for Euro 5 and Euro 6 are part of Comitology Reg 2008/692

UNLEADED GASOLINE FUEL

Parameter	Unit	Euro 4	Euro 5&6
Octane	RON/MON	95/85	95/85
RVP	KPa	56-60 [1)]	56-60 [1)]
Density at 15ºC	kg/m^3	748-775	743-756
Dist. at 100ºC	% vol	50-58	48-60
at 150ºC	% vol	83-89	82-90
FBP	ºC	190-210	190-210
Aromatics	% vol	29-35	29-35
Olefins	% vol	≤ 10	3-13
Benzene	% vol	≤ 1	≤ 1
Oxygen	% mass	≤ 1	Ethanol only
Sulfur	ppm	≤ 10	≤ 10
Lead	mg/l	≤ 5	≤ 5
Phosphorus	g/l	≤ 1,3	≤ 1,3
Ethanol	% vol	-	4,7-5,3

[1)] Different values for cold temperature test fuel: RVP: 56-95 KPa

DIESEL FUEL

Parameter	Unit	Euro 4	Euro 5&6
Cetane		52-54	52-54
Density at 150°C	kg/m^3	833-837	833-837
Distillation T50	ºC	≥ 245	≥ 245
T95	ºC	345-350	345-350
FBP	ºC	≤ 370	≤ 370
Flashpoint	ºC	≥ 55	≥ 55
Viscosity at 40°C	mm^2/s	2,3-3,3	2,3-3,3
Polycyclic aromatics	% mass	3,0-6,0	2,0-6,0
Sulfur	ppm	≤ 10	≤ 10
FAME	% vol	-	4,5-5,5
Oxydation stability	mg/ml	≤ 0,025	≤ 0,025
Oxydation stability @ 110ºC	hr	-	≥ 20

Refinery Gasoline - Blend Samples

Blendstocks, vol.%	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Reformate	52	60	51	51	36
Isomerate	12	9	8	8	17
FRN	17	10	13	----------	17
HSRN	----------	----------	----------	13	----------
Hydrocracker naphtha	17	20	25		
Heavy hydrocracker naphtha	----------	----------	----------	25	25
Coker naphtha	2	1	3	----------	5
Heavy coker naphtha	----------	----------	----------	3	----------

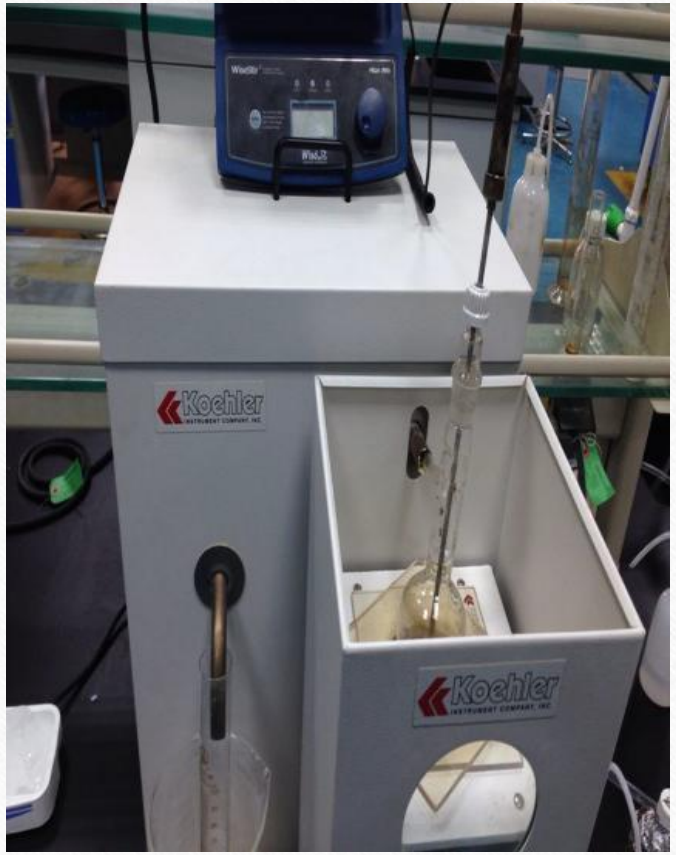
Ethanol-Gasoline Blend Samples

Blendstocks, vol. %	E0	E5	E10	E15	E 20
FRN	17	16	15.5	14	14
Reformate	36	34	31.5	31	28
Isomerate	17	16	15.5	14	14
Hydrocracker naphtha	25	24	23	22	20
Coker naphtha	5	5	4.5	4	4
Ethanol	0	5	10	15	20

ASTM Tests

Test Names	ASTM Test Numbers
Density	ASTM D1217-15
ASTM Distillation	ASTM D86-04b
Gas Chromatography	ASTM D 6839-16
Research Octane Number	ASTM D2699-15a
Motor Octane Number	ASTM D2700-16
Reid Vapor Pressure	ASTM D 323-15a
Heat of Combustion	ASTM D4809 - 13

Devices used in the research



ASTM Distillation Apparatus.

Oxygen bomb calorimeter.

Reid Vapor Pressure Tester.

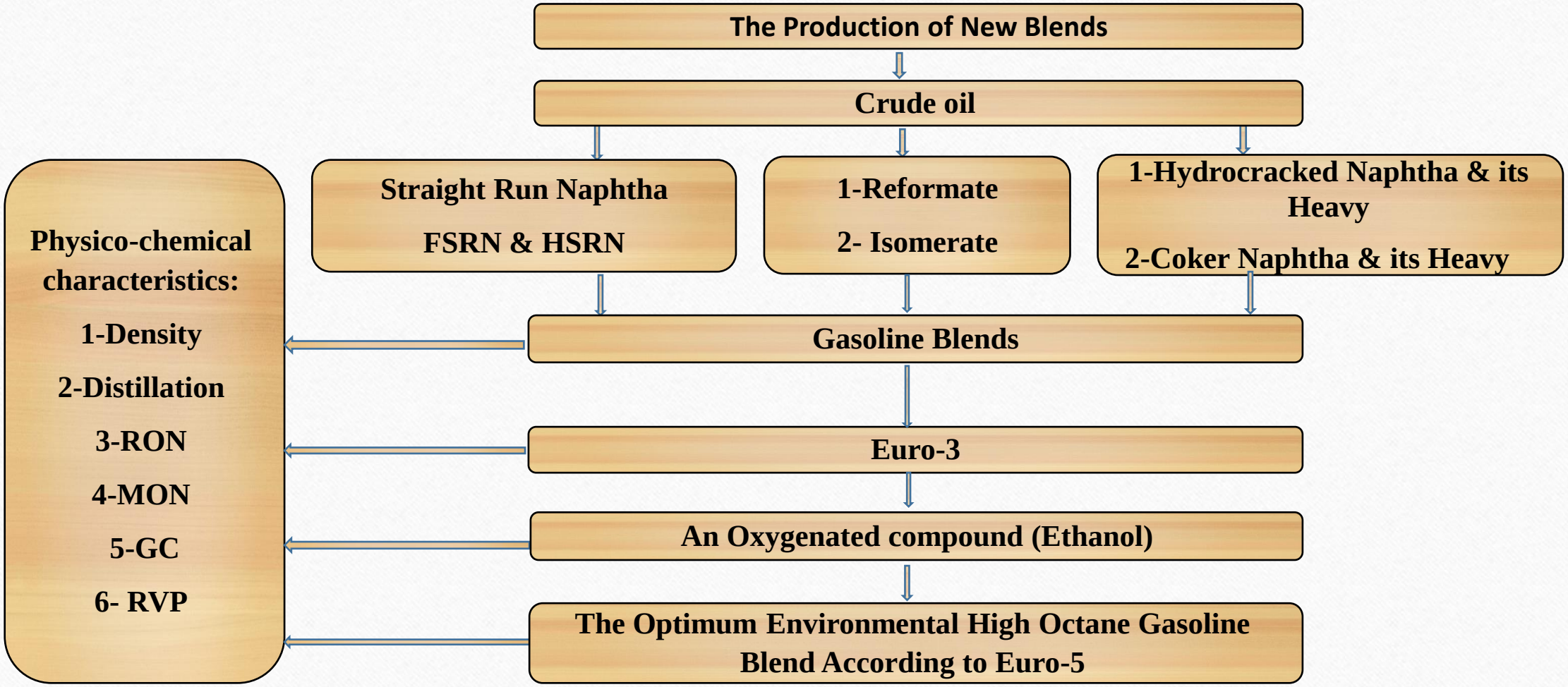
Devices used in the research

Gas Chromatograph.

Cooperative Fuel Research (CFR)) Engine.

Octane Meter Apparatus.

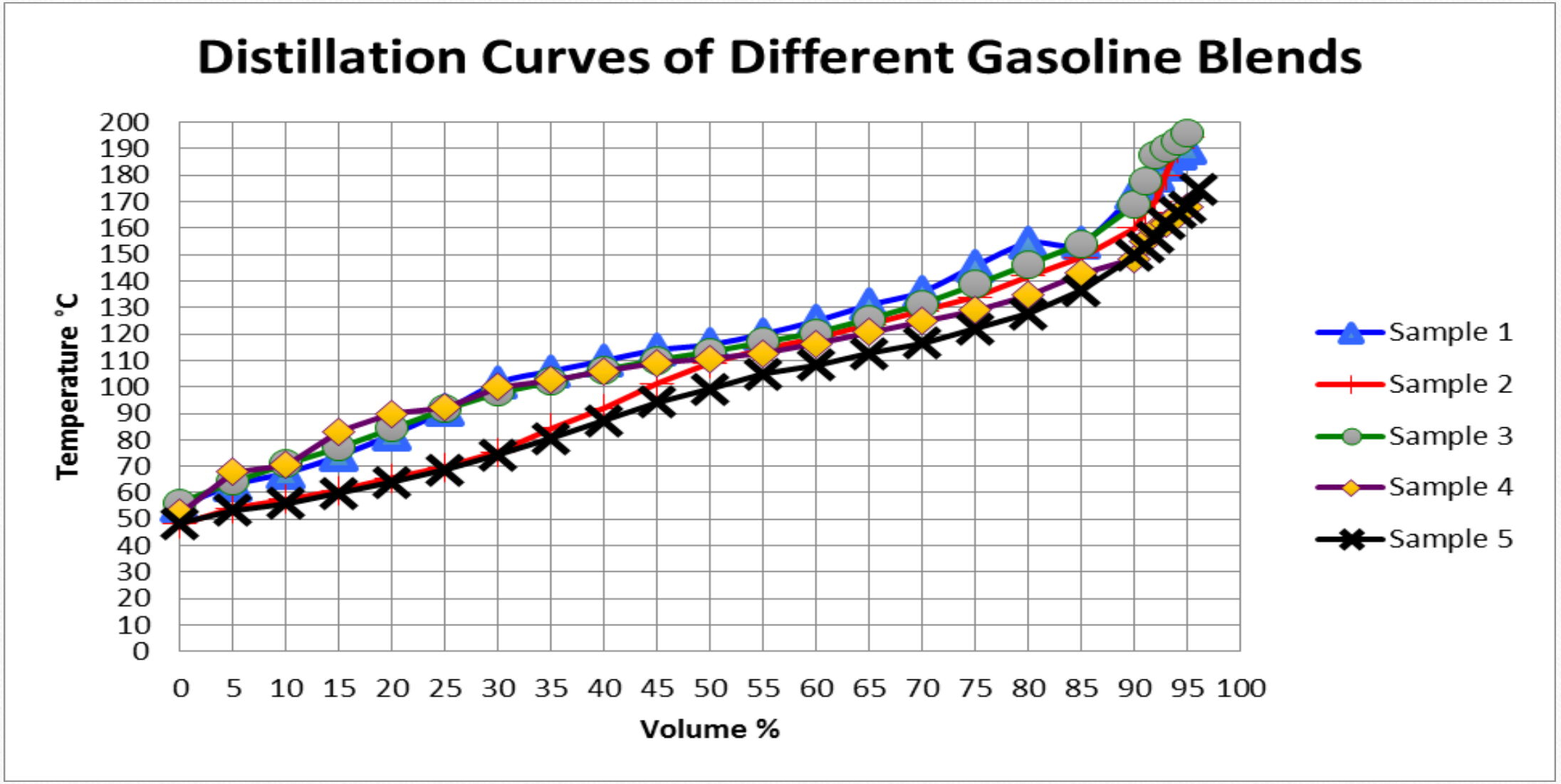
Materials and Methods



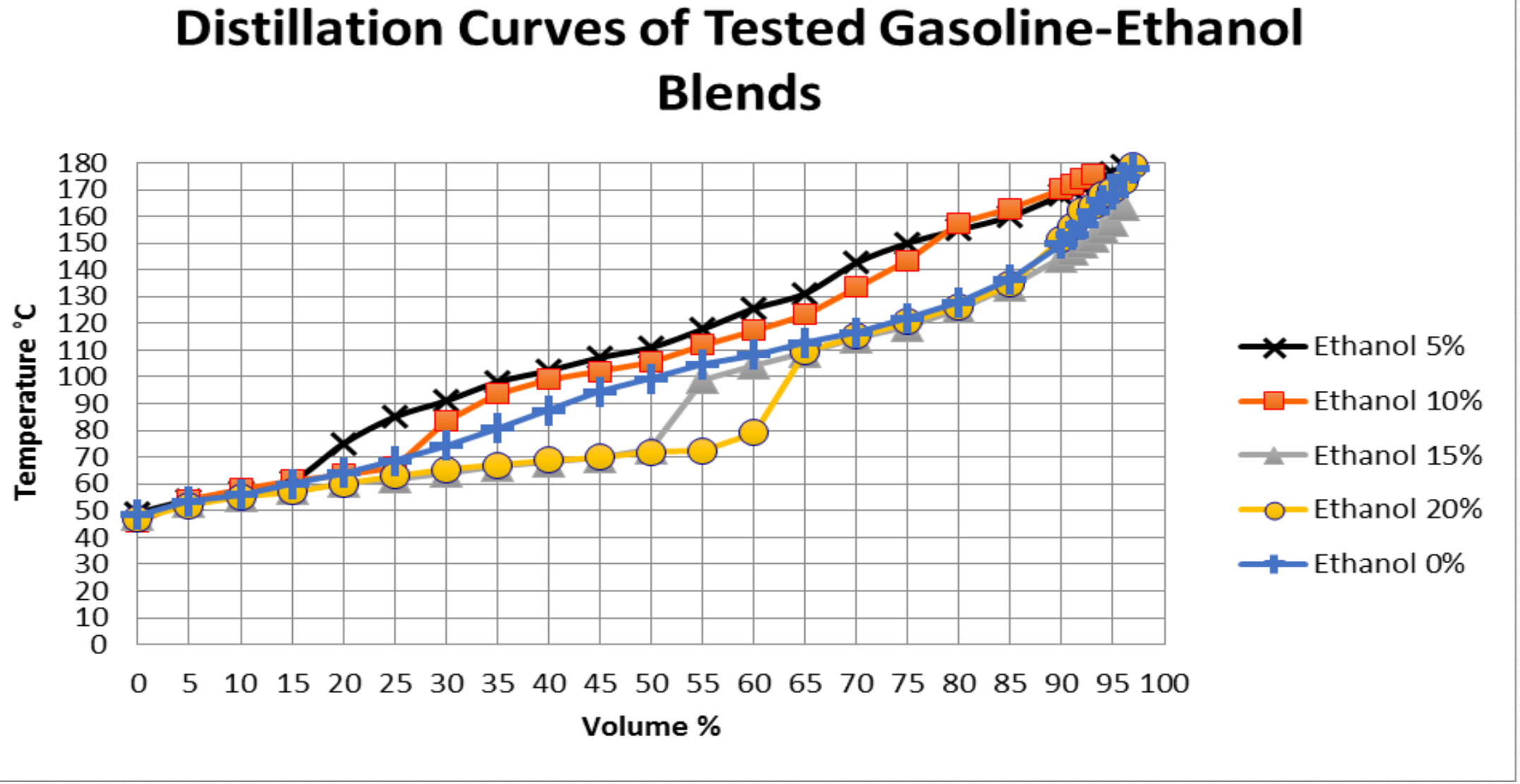
The Schematic Diagram of the Experimental Work

Results and Discussion

Results and Discussion



Results and Discussion



Results and Discussion

Physico-chemical characteristics for unleaded gasoline samples.

Test	Method	Unit	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Density @ 15.5 ^{0}C	ASTM D1217-16	kg/m^3	768.1400	772.4280	755.1124 (748-762) Euro-3	769.1600	750.5480
RVP	ASTM D323-15a	Psi	7	7.5	8.4 (8.1-8.7) Euro-3	7.2	8.6
RON	ASTM D2699-15a		95.6	98.2	95	90	88
MON	ASTM D2700-16		85.8	91.1	88	86	81.7
Aromatic	ASTM D6839-16	Vol. %	42.8420	46.6960	40 (29-42) Euro-3	40	32.6540
Paraffins	ASTM D6839-16	Vol. %	18.4680	16.3602	18.6639	18.6639	21.6228
Isoparaffins	ASTM D6839-16	Vol. %	25.2160	24.8070	26.3960	26.3960	27.8200
Naphthenes	ASTM D6839-16	Vol. %	11.8335	10.8500	12.9820	12.9820	15.1632
Olefins	ASTM D6839-16	Vol. %	1.6405	1.2868	1.9581	1.9581	2.7400
Benzene	ASTM D6839-16	Vol. %	0.68	0.78	0.66 <1 Euro-3	0.66	0.47
IBP	ASTM D86-04b	^{0}C	55	48.1	56.3	52.4	48.5
T_{10}	ASTM D86-04b	^{0}C	67.5	57.5	71	70.6	56
T_{50}	ASTM D86-04b	^{0}C	116	109	113.3	110.7	99.2
FBP@ 96 Vol.%	ASTM D86-04b	^{0}C	195	197	198 (190-215) Euro-3	170	174.8
Dist. @ 100 ^{0}C	ASTM D86-04b	Vol. %	30	45	34	30	50
Dist. @ 150 ^{0}C	ASTM D86-04b	Vol. %	75	85	83 (81-87) Euro-3	90	90

Upgraded by Ethanol blends for Euro-5

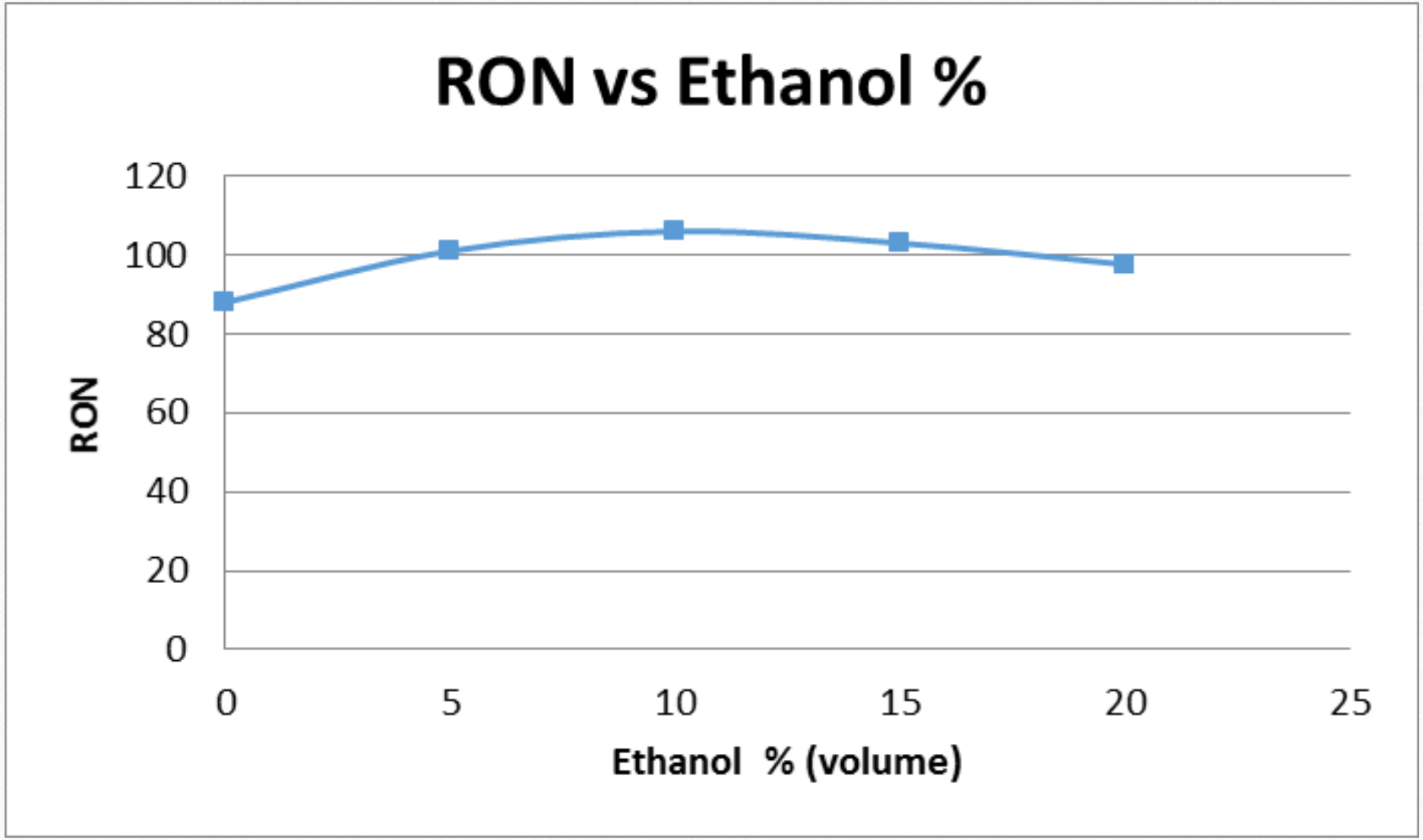
Results and Discussion

Physico-chemical characteristics for ethanol- gasoline blends.

Test	Method	Unit	E0	E5	E10	E15	E20
Density at 15.5 ^{0}C	ASTM D1217-16	kg/m^3	750.5480	745.5528 (743-756) Euro-5	739.3120	752.5500	754.1000
RVP	ASTM D323-15a	Psi	8.6	8.7 (8.1-8.7) Euro-5	8.8	7.9	7.4
RON	ASTM D2699-15a		88	101	106	103	97.6
MON	ASTM D2700-16		81.7	98	105	102	89.5
Aromatic	ASTM D6839-16	Vol. %	32.654	31.0910 (29-35) Euro-5	29.6855	28.1948	26.1013
Paraffins	ASTM D6839-16	Vol. %	21.6228	20.5910	19.6571	18.2024	18.0120
Isoparaffins	ASTM D6839-16	Vol. %	27.8200	26.4840	25.2909	24.0913	23.0232
Naphthenes	ASTM D6839-16	Vol. %	15.1632	14.4211	13.7847	13.1254	12.1240
Olefins	ASTM D6839-16	Vol. %	2.7400	2.5081	2.4909	2.0826	2.0121
Benzene	ASTM D6839-16	Vol. %	0.47	0.47 <1 Euro-5	0.46	0.46	0.45
IBP	ASTM D86-04b	^{0}C	48.5	49.3	45.6	48.2	47
T_{10}	ASTM D86-04b	^{0}C	56	57	58.2	55	55
T_{50}	ASTM D86-04b	^{0}C	99.2	111	105.6	73	71.8
FBP@97 Vol. %	ASTM D86-04b	^{0}C	178	190 (190-210) Euro-5	188	166	179
Dist. @ 100 ^{0}C	ASTM D86-04b	Vol. %	50	38	40	55	64
Dist. @ 150 ^{0}C	ASTM D86-04b	Vol. %	90	75	77.5	92.5	90
Heat of Combustion	ASTM D 4809-13	MJ/L	-	35	-	-	-

Results and Discussion

RON vs Ethanol % by volume.



Conclusions and Recommendations

Conclusions

Based on the experimental observations in the present work, the following conclusions can be drawn:

1. **The Production of environmental, clean and high octane number gasoline blends are the best solution for our environment.**
2. **The optimum unleaded gasoline sample matching Euro-3 specifications is the sample 3.**
3. **The optimum ethanol gasoline blend matching Euro-5 specifications is the sample E5.**
4. **Ethanol-gasoline-blends can be used as an alternative fuel for a variable speed spark-ignition up to 5 vol. % blends .**
5. **The high yield of gasoline production is based on different blend stocks not only straight run naphtha and reformate.**

Conclusions and Recommendations

6. **Using oxygenated compounds lead to reduce the aromatic content and consequently reduce carcinogenic compounds as well as improve octane numbers.**

7. **Maximizing the quality and quantity of an environmental gasoline according to standard European regulations (Euro-5).**

8. **An Environmental gasoline provides a great potential benefit to the refinery in view of minimizing operating costs, product quality improvement, safe and healthy living environment.**

Recommendations

The following recommendations could be put for future work:

1. **This research should be applied in the industry to prevent the hazards of air pollution.**
2. **The optimum composition of refinery gasoline blend should be applied for maximizing its quantity and quality with ethanol percentages.**


Thank You